

CLAIMS

1. A plasma treatment apparatus for activating a plasma generation gas by a discharge, and spraying an activated plasma generation gas on an object, said apparatus having a reaction vessel formed by an insulating member, and comprising a plurality of through holes, each of which has an inflow opening for the plasma generation gas at its one end, and an outflow opening for the activated plasma generation gas at its opposite end, and electrodes for developing the discharge in each of said through holes.

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2. The plasma treatment apparatus as set forth in claim 1, wherein said insulating member is configured in the form of a plate.

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3. The plasma treatment apparatus as set forth in claim 1, wherein said electrodes are embedded in said insulating member.

20 4. The plasma treatment apparatus as set forth in claim 1, wherein said electrodes are exposed to the interiors of said through holes.

25 5. The plasma treatment apparatus as set forth in claim 1, wherein said electrodes are not exposed to the interiors of said through holes.

30 6. The plasma treatment apparatus as set forth in claim 1, wherein said electrodes are disposed such that electric flux lines are generated in said through holes in a direction intersecting with a flow direction of the plasma

generation gas.

7. The plasma treatment apparatus as set forth in claim 1, wherein said electrodes are disposed such that electric flux lines are generated in said through holes in a direction parallel to a flow direction of the plasma generation gas.
- 10 8. The plasma treatment apparatus as set forth in claim 1, wherein an interval between said electrodes is in a range of 0.01 to 5 mm.
9. The plasma treatment apparatus as set forth in claim 1, wherein the openings of said through holes are formed in a circular shape with a diameter of 0.01 to 15 mm.
- 10 10. The plasma treatment apparatus as set forth in claim 1, wherein the openings of said through holes are formed in a slit shape with a short-side dimension of 0.01 to 15 mm.
11. The plasma treatment apparatus as set forth in claim 1, wherein said electrodes are formed in layers in said insulating member, and have apertures at positions corresponding to said through holes, and wherein there is no deficit portion between adjacent apertures in said electrodes.
- 30 12. The plasma treatment apparatus as set forth in claim 1, wherein said

electrodes are formed in layers to face said insulating member, and an outer peripheral portion of one of said electrodes located at a downstream side in a gas-flow direction projects outward relative to the outer peripheral portion of the other electrode located at an upstream side in the gas-flow direction.

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13. The plasma treatment apparatus as set forth in claim 1, wherein said insulating member is made of a ceramic.

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14. The plasma treatment apparatus as set forth in claim 13, wherein said insulating member is made of alumina.

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15. The plasma treatment apparatus as set forth in claim 1, comprising an electric power source for applying a pulse-like voltage with a rest period between said electrodes.

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16. The plasma treatment apparatus as set forth in claim 1, comprising an electric power source for applying a voltage with a frequency of 1 Hz to 200 kHz between said electrodes.

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17. The plasma treatment apparatus as set forth in claim 1, comprising an electric power source for applying a pulse-like voltage with a duty ratio of 0.01 to 80% between said electrodes.

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18. The plasma treatment apparatus as set forth in claim 1, wherein said

electrodes are neutral grounded.

19. The plasma treatment apparatus as set forth in claim 1, comprising gas supply means configured to supply a gas containing at least one of a noble gas, nitrogen, oxygen and air or a mixed gas of two or more of them into said reaction vessel as the plasma generation gas.
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- 10 20. The plasma treatment apparatus as set forth in claim 1, comprising a radiator for cooling said insulating member.
- 15 21. The plasma treatment apparatus as set forth in claim 1, comprising a temperature regulator configured to control temperature of said insulating member at a temperature where secondary electrons are easily emitted.
- 20 22. The plasma treatment apparatus as set forth in claim 1, comprising gas uniforming means configured to supply the plasma generation gas into all of said through holes at a uniform flow rate.
- 25 23. The plasma treatment apparatus as set forth in claim 1, wherein said reaction vessel is formed by combining a plurality of insulating members.
- 30 24. A method of producing said reaction vessel suitable for the plasma treatment apparatus as set forth in claim 1, said method comprising the steps of:

placing a conductive film formed by a conductive material between sheets having a plurality of openings and formed by an insulating material such that the openings of said sheets corresponds to each other; and

5 performing integral molding of a resultant laminate, so that said insulating member, electrode and said through holes are respectively provided by said sheets, conductive film and the openings of said sheets.

25. A plasma treatment method using the plasma treatment apparatus as set forth in claim 1, said method comprising the steps of:

developing discharges in said through holes by applying a voltage to said electrodes, while flowing the plasma generation gas from one ends to the other ends of said through holes, thereby generating plasmas in said through holes to activate the plasma generation gas; and

15 spraying the activated plasma generation gas from the other ends of said through holes on a surface of the object.

26. The plasma treatment method as set forth in claim 25, wherein the object comprises a glass material for flat panel display, printed wiring board, and a resin film.

27. A plasma treatment apparatus comprising:

25 a pair of electrode plates having a plurality of through holes; an insulating plate having a plurality of through holes, which is disposed between said electrode plates such that positions of the through holes of said electrode plates correspond to the positions of the through holes of said insulating plate;

30 gas supply means configured to supply a plasma generation gas into a

plurality of discharge spaces formed by the through holes of said electrode plates and the through holes of said insulating plate; and
voltage applying means configured to apply a voltage between said electrode plates to generate plasmas of the plasma generation gas simultaneously in
5 said discharge spaces.

28. A plasma treatment apparatus comprising a tubular vessel having a pair of electrodes and an insulating plate disposed between said electrodes, gas
10 supply means configured to supply a plasma generation gas from one end of said tubular vessel, and voltage applying means configured to apply a voltage between said electrodes to generate a plasma of the plasma generation gas in said tubular vessel, thereby performing a surface treatment to an object with the plasma ejected from the other end of said tubular vessel,
15 wherein said electrodes are provided by a pair of electrode plates having a plurality of through holes, said insulating plate has a plurality of through holes, said tubular vessel has a plurality of discharge spaces formed by the through holes of said electrode plates and the through holes of said insulating plate, and plasmas of the plasma generation gas are generated
20 simultaneously in said discharge spaces by applying the voltage between said electrode plates, and ejected from the other end of said tubular vessel.